Claims

1. Device for performing and verifying therapeutic irradiation, which comprises a radiation source (11) for a high-energy beam (1) and a means (2) for modulating the high-energy beam (1) on the gantry (14) of an irradiation device, wherein, for verification, a radiation source (10) for an X-ray beam (4) is disposed across from the radiation source (11) for the high-energy beam (1), relative to a target volume (3) of that radiation source (11) of the high-energy beam (1), such that the directions (5, 6) of the beams (1, 4) are substantially opposite, wherein a medium (12, 13) for detecting the X-ray beam (4) is disposed, relative to its direction (5), behind the target volume (3), and a medium (8, 13) for detecting the high-energy beam (1) is disposed, relative to the direction (6) of this beam (1), in front of the target volume (3), characterized in that the medium (8, 13) is designed to detect regions (16, 16', 16") of different radiation doses of the high-energy beam (1), and a controller (15) is connected to the media (8, 12 or 13) for detecting the beams (1 and 4), to the means (2) for modulation of the high-energy beam (1), to a drive for adjusting the position of the patient table (19) and to the radiation sources (10 and 11), wherein the controller (15) can be loaded with a treatment plan and is designed to control the gantry (14) and the above-mentioned devices (8, 12, 2, 10 and 11) such that

    a) before application of the high-energy beam (1) the anatomy and position of the patient (21) in the region of the target volume (3) are spatially detected via the X-ray beam (4) by directing same onto this region from various directions (7),

b) the detected anatomy and position of the patient (21) are compared with the treatment plan and the patient position and/or treatment plan are corrected, if necessary,

c) the high-energy beam (1) is applied from a first direction (7) and thereby detected with respect to its shape and areas (16, 16', 16") of various radiation doses,

d) at least one partial region of the target volume (3) including the immediate vicinity is detected by the X-ray beam (4) in a transmitting break of the high-energy beam (1),

e) the x-ray recording is compared with the detected applied high-energy beam (1) and the treatment plan is corrected, if necessary,

f) the steps c) d) and e) are repeated until the process prescribed by the treatment plan for the first radiation direction (7) is completed,

g) steps c) through f) are repeated for all radiation directions (7) provided in the treatment plan.

2. Device according to claim 1, characterized in that it is designed such that the X-ray beam (4) is directed onto at least one partial region of the target volume (3) including its immediate vicinity, from various directions, however, within a region which is sufficiently small to still substantially be opposite to the direction (6) of the rays (1) of the high-energy beam (1) and during the transmitting breaks of the high-energy beam (1), to thereby also detect the above-mentioned

detection region in three dimensions using this data detected from various directions and take it into consideration for verification in real time.

3. Device according to claim 2, characterized in that the radiation source (10) for the X-ray beam (11) is designed to describe a circular motion in a plane which is disposed about an axis (28) extending through the target volume (3) towards the radiation source (11) of the high-energy beam (1).

4. Device according to claim 1, 2 or 3, characterized in that the controller (15) is designed to consider the shape and position of the endangered organs (17) during verification and correction of modulation of the high-energy beam (1).

5. Device according to any one of the claims 1 through 4, characterized in that the X-ray beam (4) can detect a partial region of the target volume (3) together with an adjacent region of an endangered organ (17) in the transmitting breaks of the high-energy beam (1) and consider it for verification in real time.

6. Device according to any one of the claims 1 through 5, characterized in that the controller is designed to establish a protocol of the applied radiation (1).

7. Device according to claim 6, characterized in that the controller (15) is designed to establish a protocol in three-dimensional space.

8. Device according to any one of the claims 1 through 7, characterized in that the controller (15) is designed to establish a protocol

concerning the corrections of the treatment plan for the performed irradiation (1).

9. Device according to any one of the claims 1 through 8, characterized in that the media (8, 12) are designed as one medium (13) for detecting the high-energy beam (1) and the X-ray beam (4).

10. Device according to claim 9, characterized in that the medium (13) is an array of photo diodes which consist of amorphous material.

11. Device according to claim 10, characterized in that the photo diodes are disposed in a housing which only slightly attenuates the high-energy beam (1).

12. Computer program for controlling a device for carrying out and verifying therapeutic irradiation using a high-energy beam (1) which is modulated through a means (2) for radiation modulation, wherein for verification, an X-ray beam (4) is directed onto the target volume (3) in a direction (5) substantially opposite to that (6) of the high-energy beam (1) for detecting the target volume (3), and the X-ray beam (4) is detected, relative to its direction (5), behind the target volume (3) to produce an image thereof, and the high-energy beam (1) is detected in front of the target volume (3), characterized in that the program is designed to control the device using a controller (15) such that

a) before application of the high-energy beam (1), the anatomy and position of the patient (21) in the region of the target volume (3) are spatially detected via the X-ray beam (4) by directing same onto this region from various directions (7),

b) the detected anatomy and position of the patient (21) are compared with the treatment plan and the patient position and/or treatment plan are corrected, if necessary,

c) the high-energy beam (1) is applied from a first direction (7) and thereby detected with respect to its shape and areas (16, 16', 16") of various radiation doses,

d) at least one partial region of the target volume (3) including the direct vicinity is detected by the X-ray beam (4) in a transmitting break of the high-energy beam (1),

e) the x-ray recording is compared with the detected applied high-energy beam (1) and the treatment plan is corrected, if necessary,

f) the steps c) d) and e) are repeated until the application prescribed by the treatment plan for the first radiation direction (7) is completed,

g) steps c) through f) are repeated for all radiation directions (7) provided in the treatment plan.

13. Computer program according to claim 12, characterized in that it is designed to control the X-ray beam (4) from different directions during the transmitting breaks of the high-energy beam (1), wherein these directions move within a range which is sufficiently small that the X-ray beam (4) of direction (5) is still substantially opposite to the direction (6) of the rays (1) of the high-energy beam (1) and is directed onto at least one partial region of the target volume (3)

including the immediate vicinity thereof, to also take into consideration the above-mentioned detection range for verification in three dimensions and in real time using data detected from different directions.

14. Computer program according to claim 12 or 13, characterized in that the data is obtained in that the radiation source (10) for the X-ray beam (11) describes a circular motion in one plane which is disposed about an axis (28) which extends through the target volume (3) towards the radiation source (11) of the high-energy beam (1).

15. Computer program according to claim 12, 13 or 14, characterized in that it is designed such that the shape and position of endangered organs (17) are taken into consideration for verification and correction of modulation of the high-energy beam (1).

16. Computer program according to any one of the claims 12 through 15, characterized in that a partial region of the target volume (3) including a bordering region of an endangered organ (17) can be detected by the X-ray beam (14) in the transmitting breaks of the high-energy beam (1) and can be taken into consideration for verification in real time.

17. Computer program according to any one of the claims 12 through 16, characterized in that it is designed to establish a protocol concerning the applied radiation (1).

18. Computer program according to any one of the claims 12 through 17, characterized in that it is designed to establish a protocol concerning corrections to the treatment plan for the performed irradiation (1).

19. Control method for operating a device for carrying out and verifying therapeutic irradiation using a high-energy beam (1) modulated by a means (2) for radiation modulation, wherein for verification, an X-ray beam (4) is directed onto the target volume (3) in a substantially opposite direction (5) with respect to that (6) of the high-energy beam (1) to detect the target volume (3), wherein the X-ray beam (4) is detected, relative to its direction (5), behind the target volume (3) to effect an image thereof and the high-energy beam (1) is detected before the target volume (3), characterized by the following method control steps:

a) before application of the high-energy beam (1), the anatomy and position of the patient (21) in the region of the target volume (3) are spatially detected by the X-ray beam (4) by directing same onto this region from various directions (7),

b) the detected anatomy and position of the patient (21) are compared with the treatment plan and the patient position and/or treatment plan are corrected, if necessary,

c) the high-energy beam (1) is applied from a first direction (7) and thereby detected with respect to its shape and regions (16, 16', 16") of various radiation doses,

d) at least one partial region of the target volume (3) including its direct vicinity is detected by the X-ray beam (4) in a transmitting break of the high-energy beam (1),

e) the X-ray recording is compared with the detected applied high-energy beam (1) and the treatment plan is corrected, if necessary,

f) the steps c) d) and e) are repeated until the application prescribed by the treatment plan is completed for a first radiation direction,

g) steps c) through f) are repeated for all radiation directions (7) provided in the treatment plan.

20. Control method according to claim 19, characterized in that the X-ray beam (4) is directed from different directions, however, within a region which is sufficiently small that it is still substantially opposite to the direction (6) of the rays (1) of the high-energy beam (1), and onto at least one partial region of the target volume (3) including the immediate vicinity thereof during the transmitting breaks of the high-energy beam (1) to also detect the above-mentioned parameters in three dimensions and take them into consideration for verification in real time using data detected from various directions.

21. Control method according to claim 20, characterized in that the data is obtained in that the radiation source (10) for the X-ray beam (4) describes a circular motion in a plane which is disposed about an axis (28) which extends through the target volume (3) towards the radiation source (11) of the high-energy beam (1).

22. Control method according to claim 19, 20 or 21, characterized in that the shape and position of endangered organs (17) are taken into consideration for verification and correction of the modulation of the high-energy beam (1).

23. Control method according to any one of the claims 19 through 22, characterized in that the X-ray beam (4) can detect a partial region of the target volume (3) with a bordering region of an endangered organ (17) in the transmitting breaks of the high-energy beam (1) and take it into consideration for verification in real time.

24. Control method according to any one of the claims 19 through 23, characterized in that a protocol is established of the applied radiation (1).

25. Control method according to any one of the claims 19 through 24, characterized in that a protocol is established concerning corrections to the treatment plan for the performed radiation (1) application.